Automatic Toll Collection Centre (ATCC) using GSM/GPS Proposal for Indian Toll Booths

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Abstract - Open Road Tolling (ORT) is a type of electronic toll collection without the use of manual toll booths. The major advantage to ORT is that users are able to drive through the toll plaza at highway speeds without having to slow down to pay the toll and also reduces the traffic in the tolls. Toll collection in India differs from the practices in other countries. Selecting an optimum advanced technology system for ORT is the most crucial issue. This paper refers to some problems of worldwide applications in electronic toll collection systems for motorways and expressways. Most of these systems should use one or more of the following technologies: DSRC, GPS, GSM and Digital tachography. In this paper, we have analyzed the systems which meet the requirements of Indian tolls. As a result of analysis, it has turned out that only system using satellite positioning technology and mobile communications is the best toll solution of unique capabilities and this kind of technologically sophisticated system should be implemented in India. This type of system has many advantages. First, it is capable working without toll booths, extra lanes, speed restrictions or complex structures along toll roads. Second is greater adaptability and accuracy to changes in charge parameters like road classes, vehicle types etc. Third the system's ability to support other value added services on same technology like emission levels, preventing vehicle theft, over-weight detection and so on.

Keywords : ORT – Open Road Tolling, ETC – Electronic Toll Collection, ATCC – Automatic Toll Collection Centre, DSRC - Dedicated Short Range Communications, RFID – Radio Frequency Identification, GSM-Global System for Mobile Communications, GPS – Global Positioning System.

I. INTRODUCTION

In many countries, road tolling has developed rapidly since motorway construction began in the early 1960s. India has about 71,000 km of national highways, the government plans to increase toll roads from current 8500 km to at least 30,000 km in the next five years [7]. Tolls also finance major investments in existing networks, improving user safety and comfort and even environmental quality. They provide part of the financing for large projects such as bridges and tunnels, which give motorways some of their key advantages over other roads, be it safety or efficiency. ETC also helps in controlling the revenue leakages in toll booths. In India it has been estimated at least 15 per cent of the toll collection, which comes to about Rs 300 crores does not reach the government [7]. With increased circulation of people and goods throughout India, transport policies now need an exact dimension. Unlike other countries where there is a toll road and alternative road, but in India that option is not available. Hence there is always a traffic halt near toll collection centres resulting in wastage of fuel and time. This can be overcome by automizing the manual toll booths in to Electronic toll collection system.

II.COMPONENTS OF ELECTRONIC TOLL SYSTEM

Electronic toll collection systems in Figure1 rely on four major components: automated vehicle identification, automated vehicle classification, transaction processing, and violation enforcement.

A. Automated Vehicle Identification

It is the process of determining the identity of a vehicle subject to tolls. It relies on radio-frequency identification (RFID), where an antenna at the toll gate communicates with a transponder on the vehicle via Dedicated Short Range Communications (DSRC). RFID tags have proved to have excellent accuracy, and can be read at highway speeds. The major disadvantage is the cost of equipping each vehicle with a transponder. It can also use Global Positioning System location information to identify a vehicle.

B. Automated Vehicle Classification

Automated vehicle classification is closely related to automated vehicle identification (AVI). Most toll facilities charge different rates for different types of vehicles, making it necessary to distinguish the vehicles passing through the toll facility. The simplest method is to store the vehicle class in the customer record, and use the AVI data to look up the vehicle class. This is low-cost, but limits user flexibility in such cases as the automobile owner who occasionally tows a trailer. More complex systems use a variety of sensors. Inductive sensors embedded in the road surface can determine the gaps between vehicles, to provide basic information on the presence of a vehicle.

C. Transaction Processing

Transaction processing deals with maintaining customer accounts, posting toll transactions and customer payments to the accounts, and handling customer inquiries. It is referred to as a "customer service centre" and this function resembles banking, and several toll agencies have contracted out transaction processing to a bank. Customer accounts may be post paid, where toll transactions are periodically billed to the customer, or prepaid, where the customer funds a balance in the account which is then depleted as toll transactions occur. The prepaid system is more common, as the small amounts of most tolls makes pursuit of uncollected debts uneconomic. Mostly post paid accounts are maintained only with transport departments and truck operators.

D. Violation Enforcement

A violation enforcement system (VES) is useful in reducing unpaid tolls, as an unmanned toll gate otherwise represents a tempting target for toll evasion. Several methods can be used to prevent toll violators. A physical barrier, such as a gate arm, ensures that all vehicles passing through the toll booth have paid a toll. Violators are identified immediately, as the barrier will not permit the violator to proceed. However, barriers also force authorized customers, which are the vast majority of vehicles passing through, to slow to a near-stop at the toll gate, negating much of the speed and capacity benefits of electronic tolling. For example in Illinois, it requires transponder users to enter their license plate information before using the system. If the transponder fails to read, the license plate number is matched to the transponder account, and the regular toll amount is deducted from the account rather than a violation being generated. If the license plate can't be found in the database, then it is processed as a violation. An interesting aspect of such toll violation system in Illinois is a 7 day grace period, allowing toll way users to pay missed tolls online with no penalty the 7 days following the missed toll.

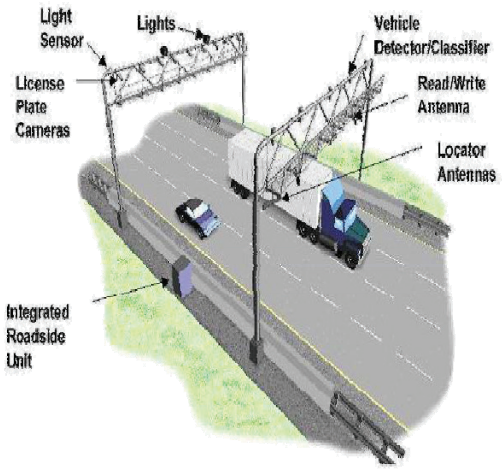

Figure 1: Components of ETC

III. ELECTRONIC TOLL COLLECTION TECHNOLOGIES

A. Dedicated Short Range Communications(DSRC)

Dedicated Short Range Communications (DSRC) used micro-wave, or sometimes Infra-red technology to transmit data over short distances between motorway systems and mobile units. Operating in the 5.8 GHz frequency range, the microwave DSRC[1] data transmission technology is similar to the technology used in RFID smart tags, which will replace bar codes at some future time.

B. Global Positioning System(GPS)

GPS is the geo-location system developed by the United States and first used in the 1980s for military applications. At the end of 1993, the US Department of Defence made the technology accessible to civilian users, and GPS [2] is now used throughout the world for geo-location, positioning and navigation. Europe is developing its own geo-location system, Galileo, which is expected to be operational in 2008. Galileo will use a constellation of 30 satellites orbiting at an altitude of 24,000 km. It will be more precise than GPS and will also offer a number of other benefits to subscribers.

C. Global System for Mobile Communications

GSM (Global System for Mobile Communication) [2] is a digital mobile telephone system that has become wireless telephone standard in Europe. In the 1980s, prior to standardization, numerous systems were in use, for example, Radiocom 2000 systems in France, NMT 450 in the Benelux and Scandinavian countries, TACS in Britain and C-Netz in Germany. Standardisation around GSM technology was the catalyst for the cell phone's immense success in Europe. In September 2001, the number of French mobile phone subscriptions surpassed the number of regular telephone lines in France. In electronic toll systems, mobile phone technologies can be used for payment transactions, be it through SMS GSM or GPRS / Edge.

D. Digital Tachography

Tachographs [2] are installed in trucks weighing over 3.5 tons, as well as in vans and buses with more than 9 seats. Similar to the "black boxes" installed on aircraft, tachographs are used to verify drivers' compliance with regulations, for example by recording the distance driven in a given period of time. Most tachographs still rely on analogue technology, with the data recorded on a paper disk. Forthcoming European regulation will require all new vehicles in this category to be equipped with digital tachographs from August 2006 and will apply to approximately 300,000 vehicles each year. A number of non-EU member states, including Brazil, India and the countries of North Africa, are also expected to adopt the same rule.

IV. PROPOSED SYSTEM

The functional concept of a manual toll system is simple: the motorist takes a ticket at the entrance to the motorway and presents it at the tollbooth at the exit. Ticketing and toll barriers can also be placed on each section of motorway [3][4]. With technological progress, these systems have evolved towards electronic toll collection, allowing traffic to flow more smoothly and improving service to both users and operators.
System consists of Automatic Toll Collection Centre (ATCC), control gates and on-board units (OBU) – Figure 2. The system is based on an innovative combination of mobile telecommunications technology (GSM) and GPS, the satellite-based Global Positioning System. The main element of the automatic log-on system is the On-Board Unit (OBU). With the aid of GPS satellite signals and other positioning sensors, the OBU automatically determines how many kilometres have already been driven on the toll route, calculates the toll based on the vehicle and toll rate information that has been entered, and transmits this information to the ATCS computer centre for further processing. Software will be support with electronic road maps and data of users registered in as well as data charges of highways and expressways. Charge counting will be started after highway entrance gate and finished after highway exit gate. Data on vehicle position will be additionally approved by GPS system and delivered to ATCC by GSM net. The toll amount is based on the truck's emission category and number of axles, as well as on the length of the toll route.

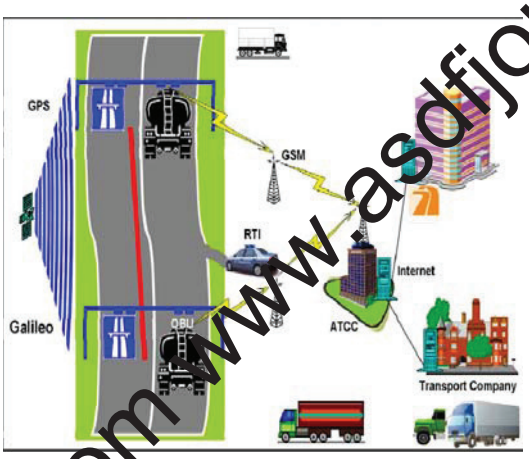

Figure 2. Proposed System Architecture

A. On Board Unit

When the vehicle is sold through a dealer, a chip is fitted with the details of the owner, Vehicle Identification number, Model of the vehicle, laden and un-laden weight, and engine and chassis number etc in presence of RTO. This chip is going to act like an On Board Unit. This unit will be tamper-proof and non-replaceable. Any attempt made to remove or replace it will break the snap lock making it impossible to install any other unit. It will be fitted within the premises of registering authority or at any other place designated by the Transport Department of the State concerned. The prototype of this unit requires to be approved by testing agencies.

A registered user can have an On-Board Unit installed and participate in automatic log-on and use all possible means paying the toll (credit account, credit card or fuel card, cash payment). Immediately after registering, the user will receive a personal user number and a master PIN number for security. After vehicle registration, the user will receive a vehicle card for each vehicle, containing the most important information about the vehicle. System has control gates equipped with IR detection equipment and high resolution cameras able to pick out vehicles via profiling (and record number plates) Toll enforcement and the punishment of violations are the responsibility of the Road Transport Inspection. The RTI has provided with the technology needed for an effective enforcement system so that RTI can enforce correct booking of the toll, thereby ensuring that all toll payers are treated equally. With the aid of this system, RTI can determine if a vehicle is has an obligation to pay toll and if it has met this

obligation fully, partially, or not at all.

B. GPS based ETC

This system does not require infrastructure along the road, such as toll data collection bridges and toll booths. The on-board unit (OBU) enables automatic usage-based toll payment. The operating principle of the OBU is based on two technologies: GPS and mobile communication (GSM). It could be even your cell phone.

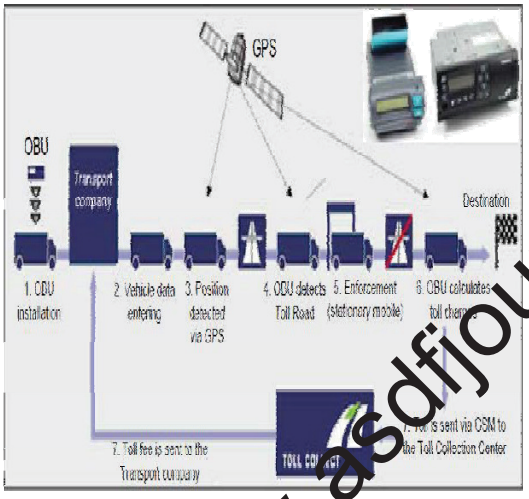

Figure 3. Postpaid GPS based ETC

The GPS mentioned in the figure 3 is made up of at least 24 satellites at a distance of 20,200 kilo-meters, which continuously sends positioning signals. The system is designed to guarantee that users and receivers will have a minimum of four satellites at their disposal at any time worldwide, regardless of the weather.

This satellite system initiated by Toll Collect uses onboard units within the trucks which are compatible with GPS technology to track the distances that individual trucks travel on toll roads. This data is wirelessly transmitted to the data center for billing. In the Figure 3, if the ETC is working based on prepaid system then the cycle stops at 6th step. The following flow chart figure 4 shows the working flow of GPS system.

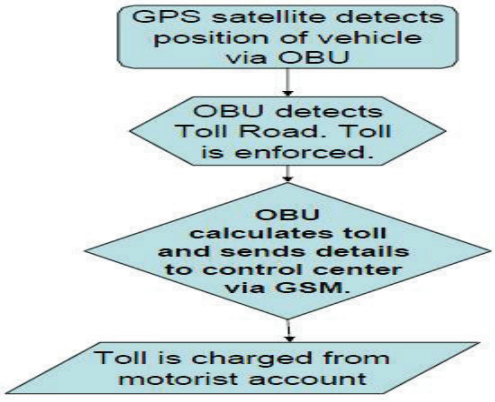

Figure 4: Working flow of GPS based ETC

V. CONCLUSION

The above mentioned technologies are future electronic toll collect systems and have different attributes, pros and cons. For many years DSRC systems have been preferred, due to their simplicity of operation, need road side equipment typically mounted on a gantry, with electronic tags in the vehicles which may be read only, read write or smart card based. The proposed system based on a combination of mobile communication technology (GSM) and a satellite based global positioning system (GPS). An innovative log on unit OBU, which automatically calculate the amount of charge due and take in to account, depends on the type of the vehicle.

It will also act like a platform for vehicle identification and prove effective in tracking stolen vehicles. With regard to future expansion and development, the satellite-based toll collection system will be a better solution, especially with regard to flexibility when it comes to extending toll collection to every road category and in terms of cost efficiency in an implementation operation.

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